How Do They Work?

There are two basic kinds of smoke detectors — ionization and photoelectric. Each senses smoke by a different principle of operation. You'll hear arguments in favor of and against each type, but the best information currently available is that either type can provide adequate home fire protection. In fact, there often appears to be more difference in performance between two models of the same type than there is between the two types.

Ionization Smoke Detectors

The *Ionization* principle depends on the fact that even a very weak source of radiation will increase the ability of air to conduct electricity. In these detectors, a small and carefully shielded bit of radioactive material "ionizes" the air in the detector's smoke chamber. As a result, a very weak electrical current flows through that chamber and is sensed by the detector's circuit.

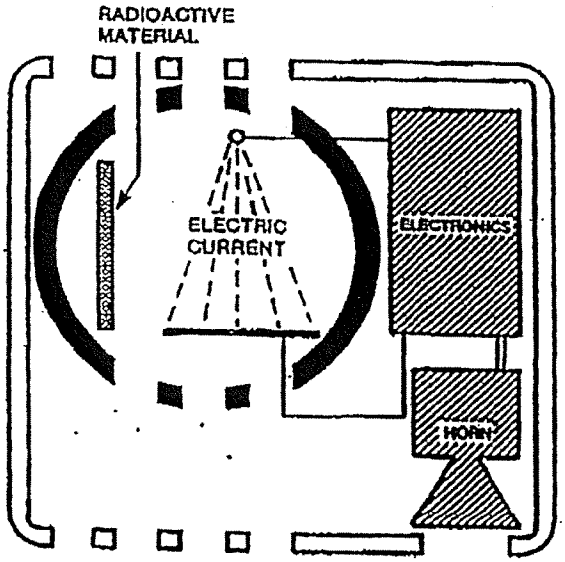
But when tiny particles of smoke drift into the chamber, they reduce that electrical current flow. When enough particles have entered the chamber, the electrical current drops below the acceptable threshold, and the detector circuit turns on the alarm horn or buzzer.

Smoke particles don't have to be very large to reduce the current flow in the ionization detector's smoke chamber. In fact, they can be invisibly small! Since hot blazing fires tend to produce more smaller smoke particles, and since these float further in the rising hot air from the fire, ionization detectors usually have a slight edge in giving early warning of open, flaming fires.

What about that radiation in ionization smoke detectors?

According to the U. S. Nuclear Regulatory Commission, if you held an ionization smoke detector close to you for eight hours a day through a whole year, you would receive only a tenth as much radiation as you'd get on one round trip airline flight across the USA.

1



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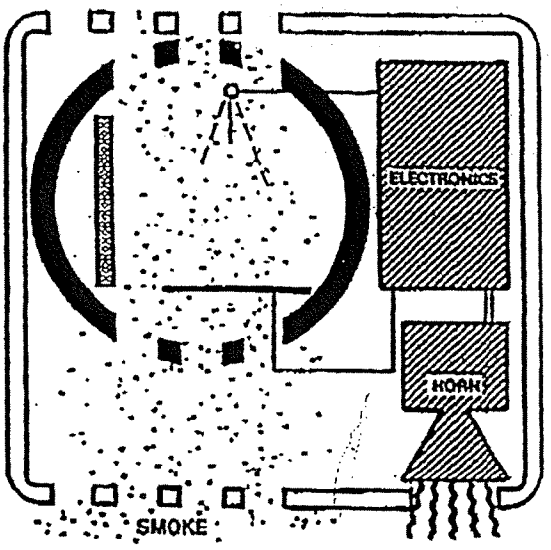
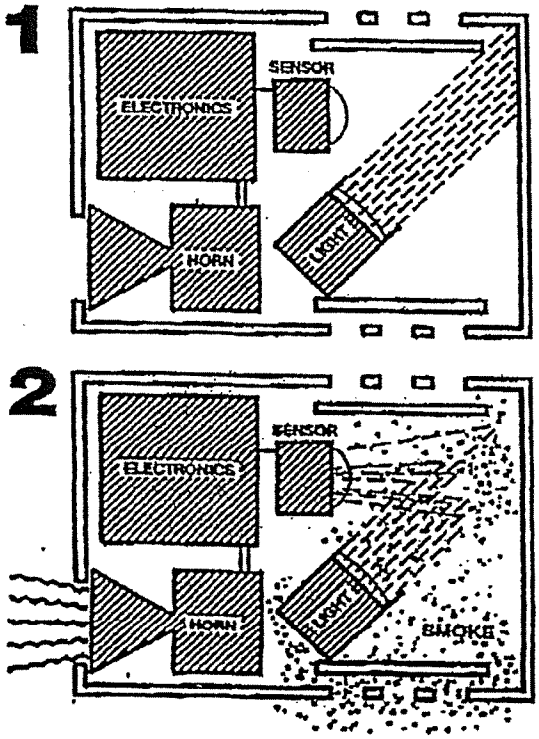


Photoelectric Smoke Detectors

The other most frequently purchased type of home smoke detector uses the photoelectric principle. It detects smoke by "seeing it" in much the same way your eyes do — by means of light reflected by the particles of smoke.

When particles of smoke are carried into the detector by room air circulating through it, they each reflect or "scatter" light from a small lamp in the device. Some of that reflected light falls on a photocell, causing it to produce a slight electrical current. As more particles enter and scatter more light onto the photocell, more electricity is generated. Finally, when the smoke particles are dense enough to reflect a pre-set amount of light, the detector circuit actuates the alarm.

Because they sense the light reflected by smoke particles, photoelectric smoke detectors detect larger particles more readily than they sense the invisible particles to which ionization detectors respond. It happens that cooler, smoldering fires produce more of these large particles than do hot, blazing fires, so photoelectric detectors are somewhat more likely to give the alarm while a fire is still smoldering.

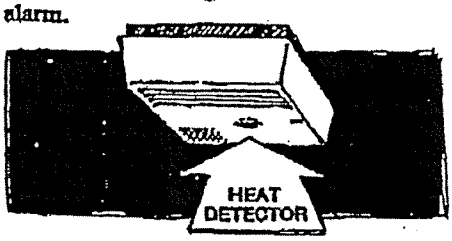


But remember that many household fires produce detectable amounts of *both* visible and invisible smoke. Either kind of detector has a high probability of giving you enough warning for a safe escape.

Of course, to really cover all the possibilities, you might want to install one of each type of smoke detector.

Do I need a heat detector too?

Some manufacturers offer a heat sensing device as either a standard or optional part of their smoke detectors, or as a separate product. Most of them use a piece of specially-formulated metal which either melts or distorts because of heat in the air around it. Heat detectors built into smoke detectors usually set off the main detector's alarm when a certain temperature is exceeded, while separate detector devices sound their own alarm or send an electrical signal to a central alarm.



Heat detectors do add protection, but they must be close to a fire to set off the alarm. They are especially useful in environments that could fool or disable a smoke detector, such as a kitchen, where grease particles in the air might cause a smoke sensor to give false alarms. Properly selected heat detectors can also be used in areas that are too hot or too cold for smoke detectors to function properly, such as furnace rooms, attics, and attached garages.

But a heat sensor is no substitute for a smoke detector. Remember, it is more often the smoke that causes injury and death than the heat of a home fire. A heat detector is capable of totally ignoring a smoldering fire that is putting out lethal amounts of smoke, carbon monoxide, and other toxic gases.

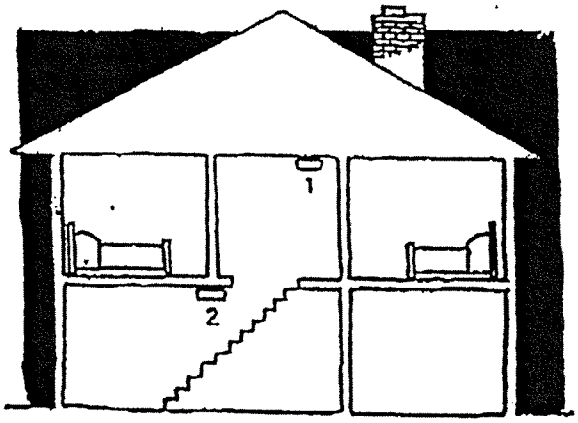
What Kind of Smoke Detector Do We Need?

Because most home fires produce a rich mixture of smoke types, with detectable amounts of both large-particle and small-particle smoke early in the fire's growth, either an ionization or a photoelectric detector will meet most needs. Rather than delay purchases while you decide between them, why not buy one and get it installed at once? Whichever type you get, it will provide more protection than no detector.

...and How Many?

This may be a more important question than "what kind?" Tests conducted for the U.S. National Bureau of Standards have shown that two detectors, on different levels of a two-story home are twice as likely to provide an adequate amount of time for escape as one detector. The upstairs detector senses smoke wherever it originates, while the downstairs unit will react sooner to fire which could block escape routes through the first floor.

One detector gives more protection than no detector; two detectors, if properly installed, provide more reliable early warning than one. Having two detectors also lets you select both an ionization type and a photoelectric model, giving you the best capabilities of both. It also lets you have one battery-powered and one plug-in or wire-in model, so that neither a battery failure nor a power outage leaves your family defenseless. Finally, two smoke detectors are far less likely, statistically, to both be "on the blink" when needed than a lone detector.



Shopping for Your Smoke Detector

Once you've decided on which type and how many, you'll discover a wide selection at your hardware, department, building supply, or discount store. In choosing, it's a good idea to look for a mark or statement on the package or the unit itself that the detector has been tested and certified by a recognized testing organization. If you don't see such a mark, or if you don't recognize the name of the testing laboratory, you can't be sure that this detector model meets minimum performance standards.

Next, look at the instructions, and ask yourself these questions:

1. Are the instructions clear and complete? They should tell you how to install it, suggest *where* to put it, and provide guidance for testing and maintenance.

2. Can you do the installation yourself — safely? Is there a step-by-step explanation, with enough diagrams to tell you exactly what you'll need to do? This is a good time to decide if you should do the installation yourself. If you don't feel confident on a stepladder, for example, you may want to ask a friend, relative, or carpenter to do it for you.

3. What maintenance is required? Do the instructions tell you how to test and clean the unit, and how often? If the unit uses batteries or replaceable lamps, is there a readily visible or audible signal to tell you when replacement is necessary? Ask the clerk if the store carries whatever parts may be needed.

Then, bring home some protection for your family.

SMOKE ALARMS

What You Need To Know

Protect Yourself and Your Family Today!

In the event of a fire, properly installed and maintained smoke alarms will provide an early warning alarm to your household. This alarm could save your own life and those of your loved ones by providing the chance to escape.

Why Should My Home Have Smoke Alarms?

In the event of a fire, a smoke alarm can save your life and those of your loved ones. They are a very important means of preventing house and apartment fire fatalities by providing an early warning signal so you and your family can escape. Smoke alarms are one of the best safety devices you can buy and install to protect yourself, your family, and your home.

What Types of Smoke Alarms Are Available?

There are many different brands of smoke alarms available on the market but they fall under two basic types: ionization and photoelectric.

Ionization alarms sound more quickly when a flaming, fast moving fire occurs. Photoelectric alarms are quicker at sensing smoldering, smoky fires. There are also combination smoke alarms that combine ionization and photoelectric into one unit, called dual sensor smoke alarms.

Because both ionization and photoelectric smoke alarms are better at detecting distinctly different yet potentially fatal fires, and because homeowners cannot predict what type of fire might start in a home, the USFA recommends the installation of both ionization and photoelectric or dual sensor smoke alarms.

In addition to the basic types of alarms, there are alarms made to meet the needs of people with hearing disabilities. These alarms may use strobe lights that flash and/or vibrate to assist in alerting those who are unable to hear standard smoke alarms when they sound.

FEMA

FA-250F / May 2007

SMOKE ALARMS *What You Need To Know*

Okay, Where Do I Put Them?

Install smoke alarms on every level of your home, including the basement. Many fatal fires begin late at night or in the early morning. For extra safety, install smoke alarms both inside and outside sleeping areas.

Since smoke and many deadly gases rise, installing your smoke alarms at the proper level will provide you with the earliest warning possible. Always follow the manufacturer's installation instructions.

Where Would I Get Smoke Alarms?

Many hardware, home supply or general merchandise stores carry smoke alarms. If you are unsure where to buy one in your community, call your local fire department (on a non-emergency telephone number) and they will provide you with some suggestions. Some fire departments offer smoke alarms for little or no cost.

Are Smoke Alarms Hard to Install?

If your smoke alarms are hardwired, that is wired into the electrical system, you will need to have a qualified electrician do the initial installation or install replacements.

For battery powered smoke alarms, all you will need for installation is a screw driver. Some brands are self adhesive and will easily stick to the wall or ceiling where they are placed.

For all smoke alarm installations, be sure you follow the manufacturer's instructions because there are differences between the various brands.

If you are uncomfortable standing on a ladder, ask a relative or friend for help. Some fire departments will install a smoke alarm in your home for you. Call your local fire department (on a non-emergency telephone number) if you have problems installing a smoke alarm.

How Do I Keep My Smoke Alarm Working?

If you have a smoke alarm with batteries:

1) Smoke Alarms powered by long-lasting batteries are designed to replace the entire unit according to manufacturer's instructions.

2) In standard type battery powered smoke alarms, the batteries need to be replaced at least once per year and the whole unit should be replaced every 8-10 years.

3) In hard-wired, battery back up smoke alarms, the batteries need to be checked monthly and replaced at least once per year. The entire unit should be replaced every 8-10 years.

What if the Alarm Goes Off While I'm Cooking?

Then it is doing its job. Do not disable your smoke alarm. All alarms due to cooking or other non-fire causes. You may not remember to put the batteries back in the alarm after cooking. Instead, clear the air by waving a towel near the alarm, leaving the batteries in place. The alarm may need to be moved to a new location. Some of the newer models have a "hush" button that silences nuisance alarms.

How Long will my Smoke Alarm Last?

Most alarms installed today have a lifespan of about 8-10 years. After this time, the entire unit should be replaced. It is a good idea to write the date of purchase with a marker on the inside of your alarm so you will know when to replace it. Some of the newer alarms already have the purchase date written inside. In any event, always follow the manufacturer's instructions for replacement.

Anything Else I Should Know?

Some smoke alarms are considered to be "hard-wired." This means they are connected to the household electrical system and may or may not have battery backup. It's important to test every smoke alarm monthly and replace the batteries with new ones at least once a year.

The U.S. Fire Administration would like to remind you of some important fire safety and prevention information:

- Plan and practice escape plans several times a year.
- Make sure your whole family knows when and how to call emergency telephone numbers.
- Obtain and learn how to use a fire extinguisher.
- Install carbon monoxide detectors.
- Consider installing residential fire sprinklers in your home.

Contact your local fire department on a non-emergency phone number if you need help or have questions about fire safety in your home.

Additional Resources

For more information on smoke alarms, please visit the USFA Web site at www.usfa.dhs.gov/citizens/.

FEMA

For more information or copies of this publication, please contact:
Department of Homeland Security / U.S. Fire Administration
16825 South Seton Avenue / Emmitsburg, Maryland 21727
800-561-3356 / www.usfa.dhs.gov

Ionization and Photoelectric Smoke Alarms

With this guidance document, the National Association of State Fire Marshals (NASFM) hopes to convey to State Fire Marshals a summary of current information about the research on ionization and photoelectric residential smoke alarms. It aims to explain the different response characteristics of these two types of alarms and offer advice for what to tell the public about smoke alarm use.[1] It is important to note that smoke alarms are only one component of a comprehensive residential fire protection plan.

A comprehensive study on residential smoke alarm technology was recently completed by the National Institute of Standards and Technology, along with Underwriters Laboratories, the US Fire Administration, the US Consumer Product Safety Commission, the US Centers for Disease Control and Prevention, and other sponsors. This work evaluated current and emerging smoke alarm technology responses to common residential fire scenarios and nuisance alarm sources (the link to published work on the NIST website is http://smokealarm.nist.gov/). While additional research continues, the following information can be verified at this time.

Early detection of fires is crucial to escape time, because the time to untenable conditions in residences can be as little as 3 minutes for typical flaming fire scenarios. Both ionization and photoelectric smoke alarm technologies quickly alert occupants in most fire scenarios. In controlled experiments, ionization alarms react earlier than photoelectric alarms in fast-flaming fires, such as those involving paper or flammable liquids, while photoelectric alarms tend to react substantially earlier than ionization alarms in smoldering fires, such as those ignited by cigarettes in upholstered furniture, bedding materials, and mattresses.

Experts recommend that a home have both ionization and photoelectric alarms or dual alarms to ensure the fastest response to both flaming and smoldering fires. Ionization alarms cost about $5 retail, photoelectric alarms cost about $20 and dual alarms cost about $30.

It is most important to get working smoke alarms in 100% of residences. They should never be disabled. Smoke alarms must be tested, cleaned and replaced according to manufacturers' instructions.

NASFM and its Science Advisory Committee suggest that State Fire Marshals include the following information when they educate the public about the use of smoke alarms:

- Smoke alarms save lives, prevent injuries, and minimize property damage by detecting and alerting residents to fires early in their development. The risk of dying

[1] NASFM is grateful to its Science Advisory Committee, Consumer Product Safety Task Force and Public Education Committee for their contributions to this document.

from fires in homes without smoke alarms is twice as high as in homes that have working smoke alarms.

- There are two main types of smoke alarms, and both detect all types of growing fires. Ionization alarms, which sell for about $5 for battery-operated models, respond faster to flaming fires, such as those involving paper or flammable liquids. Photoelectric alarms, which sell for about $20, respond faster to smoldering fires, such as those ignited by cigarettes in upholstered furniture, bedding materials, and mattresses. Dual ionization/photoelectric alarms are also available, and cost about $30.

- To ensure that both smoldering and flaming fires are detected as quickly as possible, the best protection is to have both types of alarms installed, or dual ionization/photoelectric alarms.

- Working smoke alarms should be installed on every level of the home, outside sleeping areas and inside bedrooms, per manufacturer's specifications. Locate smoke alarms away from air vents or registers, and avoid other spaces with high airflow.

- All smoke alarms must be kept free of dust and insects. Current manufacturers' guidance is to test alarms weekly and clean them monthly to make sure they operate properly. If the unit is battery operated or has battery back-up, the batteries should be replaced at least once a year. In addition, experts say that the smoke alarm unit itself should be replaced every 10 years.

- Never remove the batteries to disable a smoke alarm, even if you experience "nuisance" alarms, such as while cooking or showering. Fan the detector with a newspaper or towel to stop the alarm. Clean the smoke alarm according to the manufacturer's instructions, and if possible relocate it away from the kitchen or bathroom. Some smoke alarms have a silencing feature, so nuisance alarms can be stopped quickly and easily.

- Evidence indicates that some children may not awaken from the sound of a smoke alarm. Parents should hold a fire drill during the night so they can assess their children's ability to awaken and respond appropriately. If children, or any other family members, do not awaken to or hear the smoke alarm, the home escape plan should be adjusted accordingly to help get all family members out safely. NASFM is aware of certain types of alarms that project a recording of the parents' voice or some other sound to which children may be more responsive than the traditional alarm.

- For elderly people, those who have impaired hearing or those who have other disabilities that make the alarm difficult to hear, there are smoke alarms that use strobe lights and vibrators in addition to sound. Exploring alternative approaches such as these may make sense in those households.

- Develop and regularly rehearse an escape plan with all members of your household, so that when the smoke alarm sounds, everyone will move to a safe location outside the home. For information on how to develop a home escape plan, see http://www.nfpa.org/assets/files/PDF/FPWgrid03.pdf.

Approved by NASFM Board, April 2006

PB247483

DETECTOR SENSITIVITY AND SITING REQUIREMENTS FOR DWELLINGS

IIT RESEARCH INST., CHICAGO, ILL.
ENGINEERING MECHANICS DIV

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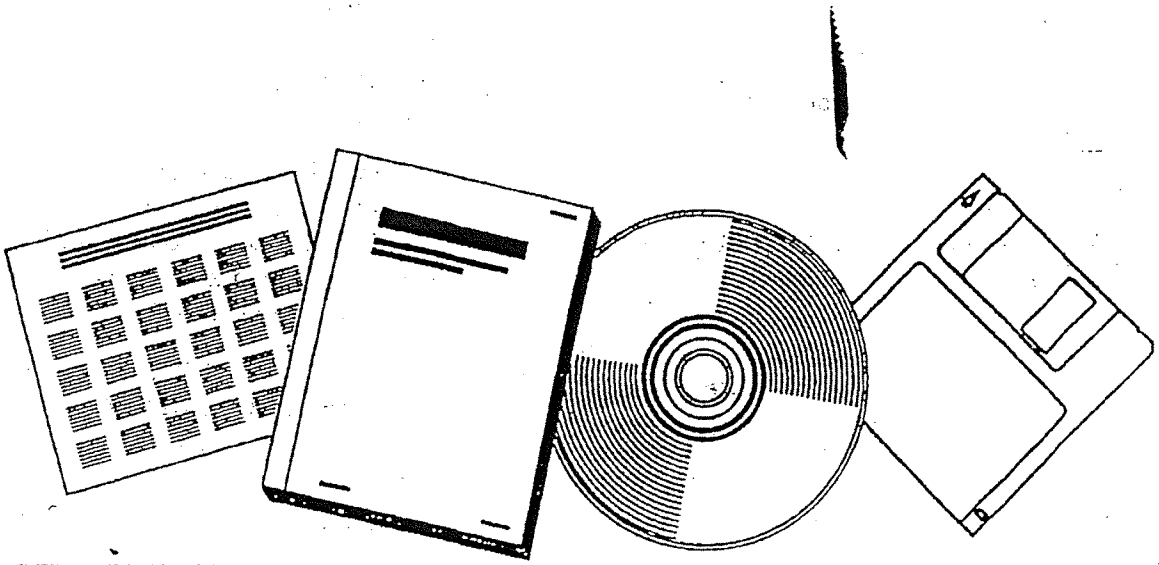


U.S. DEPARTMENT OF COMMERCE
National Technical Information Service

Another unexpected observation during the fires was the slowness of smoke movement throughout the building. All of the experiments, and especially the basement fires, showed that the smoke moving up stairways tended to move in a clearly defined front and at a very slow rate. It was often the case that, when this defined front reached the detectors, a number of the detectors responded almost simultaneously.

CONCLUSIONS:

1. A residential smoke detector of either the ionization or photoelectric types with small lag time would provide more than adequate life saving potential under most real residential fire conditions when properly installed. Even in the case of rapidly building flaming ignition fires the detectors would provide adequate warning before dangerous conditions were reached in the primary escape path.

2. Whereas detectors set at nominal 2 percent per foot obscuration generally provided adequate warning, those detectors whose sensitivities were near 1 percent per foot (actual) provided a considerable increase in escape time for smoldering fires. The effect was much smaller for flaming fires.

3. Fixed temperature (135 F) or rate-of-rise heat detectors in the room of fire origin provided little life saving potential. These detectors failed to respond to a majority of the fires and when they did respond they were considerably slower than smoke detectors located remote from the fire.

4. In the building during forced air heating, there appears to be very little difference in smoke levels obtained in the bedroom with the bedroom doors open or closed. Under central air conditioning, however, greatly reduced smoke levels were obtained in the bedrooms with the doors closed.

Experiments conducted with fires in closed bedrooms resulted in lethal conditions in the bedroom before response of detectors outside the bedroom. Thus, the person in the room of fire origin would not be saved unless the detectors were in the bedroom or the door was open.

5. Response time of detectors on the second floor for first floor fires should be considered inadequate. Thus, it would appear that NFPA/74 should be revised to require at least one detector on each level of a residence.

6. Installation of one smoke detector at each end of a long central hall would significantly increase the escape time potential in comparison with one detector at one end of the hall.

7. It appears that there is no difference in life saving potential between ionization and photoelectric detectors under expected residential fire conditions when taken as a whole. Although some response difference is noticed depending on the type of combustion, (flaming or smoldering) the differences are minimal when compared on an escape time and life saving potential basis. Detectors operating on the dual gate principle appear less advantageous than either the ionization or photoelectric types.

8. Smoke conditions produced by the fires indicate that there should be no significant difference in detection times for ceiling mounting or wall mounting within 12 in. of the ceiling. However, individual detectors with highly directional properties may function quite differently in these two positions.

5.0 RECOMMENDED AREAS FOR FURTHER STUDY:

A number of conclusions which emerge from this series of experiments seem to have great significance to development of requirements for installation of residential fire detection systems. Accordingly it is essential that these be verified in additional experiments. Specifically, the following items need further study.

1. The differences between smoke distribution by the HVAC system under heating and cooling conditions should be investigated in other buildings and for both single and double duct systems. Summer conditions should be further investigated to include fires originating just after the HVAC system shuts off and where air conditioning is not used.

2. Further similar experiments should be carried out in other building geometries to determine if the results of these experiments are specific to these geometries.

3. Some experiments should be carried out in these and other test buildings to determine the effect of open windows on fire conditions and detector response.

4. Experiments should be carried out to determine what affect NFPA/74 protection levels 1, 2 and 3 have on increasing the escape time over those obtained with a level four type installation. This data could be well applied in determining the cost effectiveness of providing these much more expensive detection systems.

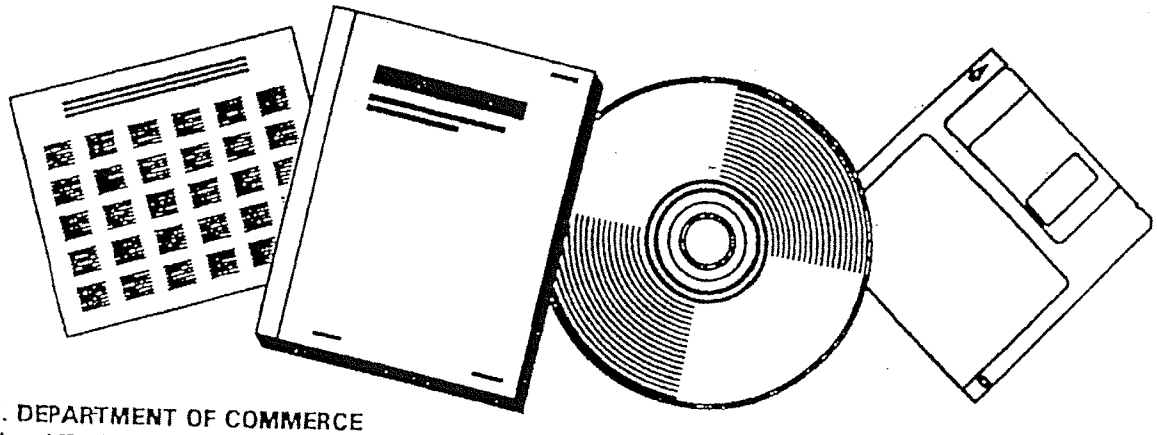
5. Consideration should be given to the development of one or more standardized fire which could be used as a correlation test for various building geometries and ambient conditions.

PB263-882

DETECTOR SENSITIVITY AND SITING REQUIREMENTS FOR DWELLINGS - PHASE 2

ENGINEERING MECHANICS DIV.
CHICAGO, IL

FEB 77



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National Technical Information Service

CONCLUSIONS

In general, the results stated in this Report support and expand on the results obtained in the original work.

1. A residential smoke detector of either the ionization or photoelectric type set at the sensitivity levels encountered during this study would provide adequate life saving potential under most real residential fire conditions when properly installed. Once again, even in the case of rapidly building flaming ignition fires the detectors would provide adequate warning before dangerous conditions were reached in the primary escape path.

2. Supporting the first year results, the fixed temperature heat detectors rated for 50 ft spacing (135 F) used in this test series, in the room of fire origin, provided little life saving potential. These detectors failed to respond to a majority of the fires and when they did respond they were considerably slower than smoke detectors located remotely from the fire.

3. Response time of detectors on the second floor for first floor fires should be considered inadequate. Thus, once again it appears that NFPA No. 74 should be revised to require at least one smoke detector on each level of a residence.

In addition to the above, the data taken at the Wabash residence strongly suggests that a detector used in the basement of a residence should be located on the basement ceiling and not at the top of the basement stairway.

4. Installation of one smoke detector at each end of a long central hall would significantly increase the escape time potential in comparison with one detector at one end of the hall. Both this and the previous study suggest installation of a smoke detector approximately every 30 ft in a long hallway.

5. As in the first year study, there is no apparent difference in life saving potential between ionization and photoelectric detectors under the fire conditions tested during this series. Although the photoelectric detectors in general respond better to a smoldering fire, and ionization type detectors in general respond better to a flaming fire, the time difference between these detectors are minimal when compared on an escape time and life saving potential basis.

6. The level of technology represented by the semiconductor gas sensors employed during this test series did not provide adequate life saving potential and reliable operation as compared to the conventional type detectors used. The sensors used were erratic in behavior and very sensitive to transients and contamination of the semiconductor crystal.

7. In the Whitehouse residence, having certain windows open while performing fires under summer conditions, did not adversely affect detector response time and escape potential.

8. The simulated polyurethane mock-ups did not produce a fire equivalent to those where actual furniture with polyurethane was used. The buildup of smoke and products of combustion was faster than in the actual furnishings fires. Evidently, the simple mock-ups used in this test series were not sufficient, and closer matching to the real item construction is required before fires of this configuration can be used.

5.0 RECOMMENDED AREAS FOR FURTHER STUDY:

Upon review of the results obtained for the research performed under this study, it is evident that basing Standards for fire detection location and sensitivity on laboratory data and engineering judgement is not sufficient to assure positive life saving potential. Accordingly, it is essential that these Standards be verified in additional actual field testing. After reviewing this year's results, the following items are proposed for further study.

1. Experiments should be performed in a split level residence to determine the protection level requirements for this type of building. Every level protection is not clearly defined for this building layout.

2. Detector response to fires originating in structural components due to electrical overload or improperly spaced flues, etc. should be examined. The Wabash Avenue site could serve this purpose since the site is to be demolished in the near future and these tests might cause significant structural damage. More specifically, experiments could be set up for exposed studding in a furnace room being overheated from a radiant source or overloading segments of wiring in stud spaces. The effect of fires exterior to wood joist construction could be studied by preparing exterior wall sections to inset in the overhead door spaces on either end of the "family room".

3. Since the HVAC system at the J. R. Whitehouse residence was marginal in capacity and did not adequately mix the cool air into each room, detector response to fires in a building having a high volume air conditioning system should be studied. For this testing a new site would have to be searched for, but if necessary the Whitehouse residence could be modified for this purpose.

4. Detector performance in commercial, industrial, and public buildings should be studied in regard to public and property protection.

5. Research should be performed to study the relationship between distance, volume, and required detector sensitivity in a large volume residence to determine if a more accurate method of siting detectors could be established.

6. Although touched upon in this year's study, further experimentation with monitoring the respiration rate of mice at different locations in a residence may prove to be a valuable tool to more accurately define escape criteria for humans.

7. Further study is needed of detectors exposed to synthesized fires in real residences. Although this was touched upon at the Wabash Avenue site for this test series, a more extensive study may aid development of a more accurate, meaningful bench test. The present bench test smoke generation methods could be duplicated as well as an examination carried out on other simple fire and/or smoke sources at full scale. Comparisons could then be made between these results and those with actual furnishings.

NIST Technical Note 1455

Performance of Home Smoke Alarms
Analysis of the Response of Several Available Technologies in Residential Fire Settings

Richard W. Bukowski
Richard D. Peacock
Jason D. Averill
Thomas G. Cleary
Nelson P. Bryner
William D. Walton
Paul A. Reneke
Erica D. Kuligowski

NIST National Institute of Standards and Technology • Technology Administration • U.S. Department of Commerce

9 Conclusions

1. The data developed in this study include measurement of temperature and smoke obscuration in addition to gas concentrations for a range of fire scenarios and residences. Measurement of the response of smoke alarms, CO alarms, heat alarms, and tell-tale sprinklers are also included. These data could be of significant value in developing appropriate algorithms for alarms that may include one or more sensor types.

2. Smoke alarms of either the ionization type or the photoelectric type consistently provided time for occupants to escape from most residential fires.

   a In many cases, available escape time would be sufficient only if households follow the advice of fire safety educators, including sleeping with doors closed while using interconnected smoke alarms to provide audible alarm in each bedroom, and pre-planning and practicing escape so as to reduce pre-movement and movement times.

   b. Smoke alarms may not provide protection for people directly exposed to the initial fire development (so-called "intimate with ignition").

   c. Consistent with prior findings, ionization type alarms provided somewhat better response to flaming fires than photoelectric alarms, and photoelectric alarms provided (often) considerably faster response to smoldering fires than ionization type alarms.

   d. Smoke alarms of either type installed on every level generally provided positive escape times for different fire types and locations. Adding smoke alarms in bedrooms increased the escape time provided by as much as 900 s, especially for smoldering fires. It is important to note that the available safe egress times may overlap with the range of estimates of necessary egress time for the residences studied. Some of this is due to conservative tenability criteria based on incapacitation of the most vulnerable occupants that was used for the current study. Use of tenability criteria based on incapacitation or death of healthy individuals would certainly increase the available safe egress time.

   e. Escape times in this study were systematically shorter than those found in a similar study conducted in the 1970's. This is related to some combination of different criteria for time to untenable conditions, improved understanding of the

speed and range of threats to tenability, and faster fire development times for today's products that provide the main fuel sources for fires, such as upholstered furniture and mattresses. It is important to note that while both the 1975 study and the current study attempted to use a representative sample of available and important furnishings, each study included only a small fraction of those available in the marketplace. Still, this study is consistent with other recent studies of furniture and mattresses even though there may be significant differences in the burning behavior between items of furniture.

f. A mechanically aspirated (system-type) photoelectric smoke detector included in the study consistently responded after the other photoelectric smoke alarms, even for smoldering fires where convective flow rates are low and smoke entry might be an issue. Since only one such alarm was included in the study, more general conclusions cannot be drawn.

g. Residential sprinklers activated well after the smoke alarms and after the heat alarms in all of the scenarios. While these sprinklers have an outstanding record of saving lives and property, the later activation time implies that residential sprinkler installations should always include smoke alarms (as currently required in NFPA 13D and 13R) to provide greater escape times for those capable of escaping.

4. Experiments conducted with common nuisance sources produced data that should be useful in the development of new performance requirements for conditions that should not activate smoke alarms. Since the data includes analog signal levels and duration for each of the sensor types they should be useful in evaluating a range of approaches to nuisance alarm reduction from reducing alarm threshold for a specified time ("hush" feature) to decision algorithms and multi-sensor arrays.

STUDIES ASSESS PERFORMANCE OF RESIDENTIAL DETECTORS

By

Richard W. Bukowski
Building and Fire Research Laboratory
National Institute of Standards and Technology
Gaithersburg, MD 20899

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